# keeping it clean IN PEARL HARBOR

## NEW COPPER LIMITS PROVE NAVAL OPERATIONS CAN WORK WITHIN ENVIRONMENTAL STANDARDS

For the first time since 1997, the Pearl Harbor Naval Shipyard and Intermediate Maintenance Facility (PHNSY & IMF) has an uncontested National Pollution Discharge Elimination System (NPDES) permit. The NPDES permit program controls water pollution by regulating point sources that discharge pollutants into U.S. waters. Receiving this permit enables the shipyard to continue critical ship and submarine maintenance activities while staying within environmental guidelines.

**The EPA has published procedures and methods to establish site-specific permit limits that are based on sound science and are protective of the environment.**

This success was the result of a multi-year effort at the shipyard to address permit requirements for the low level discharge of copper into the marine environment. With support from the Environmental Sciences Branch at the Space and Naval Warfare Systems Command (SPAWAR) Systems Center, Pacific (SSC Pacific) the shipyard executed a comprehensive study to support a scientifically based derivation of their discharge limit for copper adhering to U.S. Environmental Protection Agency (EPA) guidance.

In December 2001, the Environmental Office at PHNSY & IMF contacted the Environmental Sciences Branch at SSC Pacific to request technical assistance with compliance issues related to the State of Hawaii's planned issuance of a new NPDES permit for the discharge of shipyard effluents to Pearl Harbor. Specifically, the NPDES permit was issued with a discharge limit for copper that the shipyard determined was unattainable. The shipyard contested the limit and was given an interim limit for copper while SSC Pacific completed a comprehensive study. After continued communication with the Hawaii State Department of Health, the results from this comprehensive study were incorporated into a new NPDES permit for the shipyard.

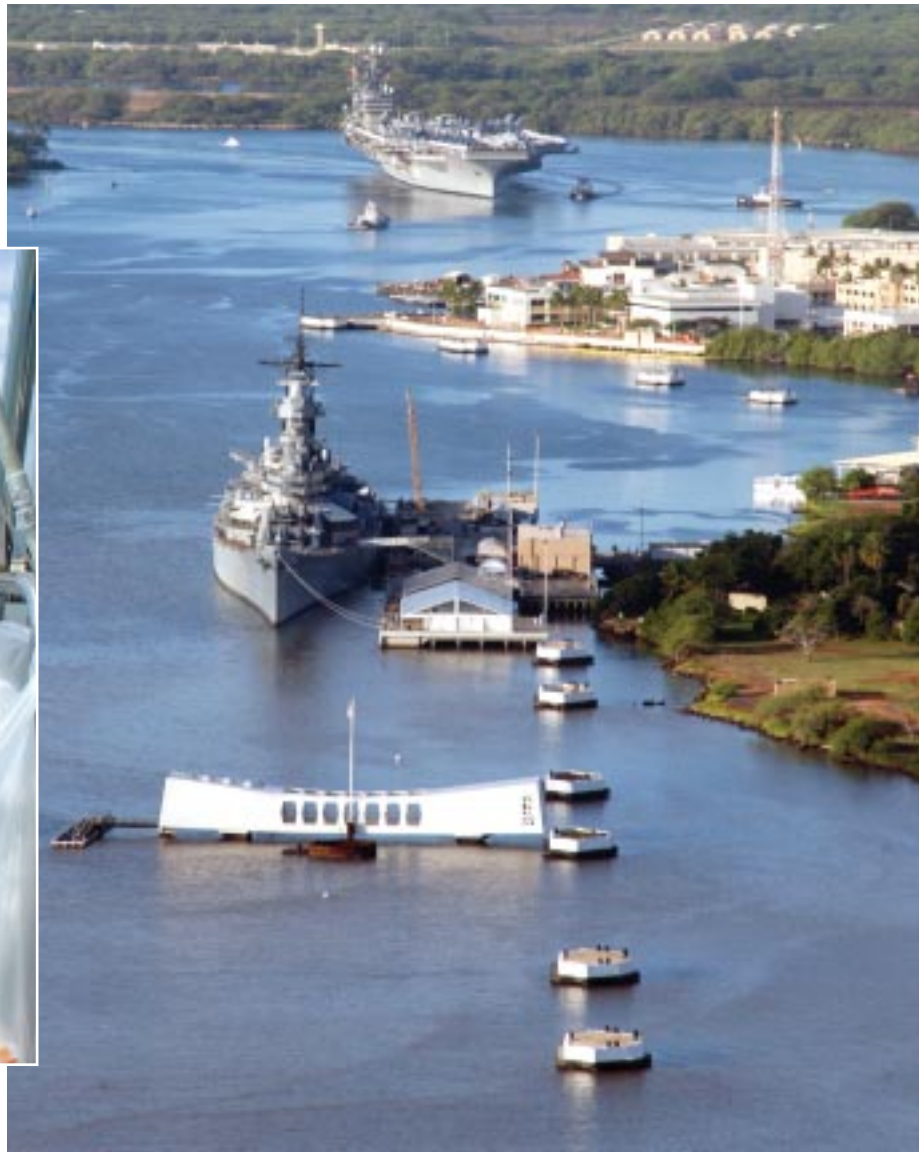
## NOT ALL ECOSYSTEMS ARE ALIKE

The National Water Quality Criteria (WQC) is a set of recommended water quality criteria for the protection of aquatic life and human health in surface water for approximately 150 pollutants. The WQC are designed to protect all waters of the United States and therefore can be overprotective of individual water bodies. The EPA has established methods for a permittee to recalculate the WQC rendering it more representative of species occurring at a specific site and still be protective of the environment. The recalculation procedure involves corrections, additions and deletions of the data that are used to calculate National WQC.

For Pearl Harbor, the procedure used a more comprehensive toxicity data set than the EPA data. This effort resulted in a recalculation of the Pearl Harbor WQC which yielded in acute and chronic criteria of 7.8 and 5.0 micrograms per liter (µg/L) dissolved copper, respectively. These criteria provide the level of protection intended by the EPA for those facilities that discharge copper into Pearl Harbor.

**TOXICITY DATA SET**

| *Action* | *Species* | *Reason* |
|---|---|---|
| Addition | Hawaiian collector urchin (*Tripneustes gratilla*) | Present, sensitive |
| Addition | Lace coral (*Pocillopora damicornis*) | Present, sensitive |
| Addition | Red tilapia (*Oreochromis mossambicus*) | Present |
| Deletion | Bay mussel (*Mytilus sp.*) | Not present, but oyster is present |
| Deletion | Summer flounder (*Paralichthys dentatus*) | Not present, irrelevant life stage |
| Correction | Eastern oyster (*Crassostrea virginica*) | Newer measured data available |



ABOVE and RIGHT: A scientist from the SPAWAR Systems Center Pacific using clean sampling techniques in Pearl Harbor.

## OVERALL TECHNICAL APPROACH

The EPA has published procedures and methods to establish site-specific permit limits that are based on sound science and are protective of the environment. These procedures result in changes that are mathematically applied to increase a permit limit. Because the national standards reflected a regulatory limit for copper low enough to threaten business operations at Pearl Harbor, all options need to be considered. The technical approach executed by SSC Pacific consisted of the following steps to address copper contamination and regulation at the shipyard:

- Conduct a pollution pathway analysis and detailed characterization of shipyard discharges for dissolved and total copper, using appropriate clean trace metal testing methods.
- Develop and implement an improved Best Management Practices (BMP) program to target cost-effective means to significantly reduce copper loads from the shipyard.

Identifying the industrial operations and processes that contribute copper to the discharge requires an upstream evaluation of the individual components of the discharge.

- Conduct studies to derive site-specific water quality objectives for copper including a recalculation procedure and a Water Effect Ratio (WER).
- Perform a chemical translator study to derive a site-specific formula for converting between dissolved and total recoverable metals for copper.
- Provide scientific basis for the assignation of a mixing zone where appropriate.

When these study elements were combined, a new permit limit was calculated and expressed as Total Recoverable Metals (TRM).

## DISCHARGE CHARACTERIZATION

The complex industrial setting at naval shipyards and the assortment of water sources used within them is evident in the variability of metal concentrations and mass loads in the effluents (discharge). At PHNSY & IMF, variability is exacerbated by temporal fluctuations of the input water sources, weather patterns and contributions from five major streams into the Pearl Harbor Estuary. Identifying the industrial operations and processes that contribute copper to the discharge requires an upstream evaluation of the individual components of the discharge.

The copper loading in effluents from the shipyard is heavily influenced by rain events. While the background copper load associated with rainwater is itself insignificant, rain causes resuspension of insoluble particles already present on the dry dock, resulting in the much higher copper loads. The average copper concentration in the effluent tripled during rain events. These results indicate that controlling rain runoff and better cleaning efforts as well as source particle emissions should yield lower copper concentrations and associated loads in the effluent.

During dry conditions, non-contact cooling water is the primary contributor to the copper load in the effluent. In dry conditions, non-contact cooling water accounts for 73–90 percent of the total copper loading in the dry docks. During wet conditions, it was estimated that runoff into the dry docks and discharges from the floor and sumps of the dry docks accounts for 73–80 percent of the copper loading in dry docks. These calculations were conducted with estimated flows, and the results attest to the importance of reducing particles in the dry docks under any circumstance.

There are two other sources of copper loading: freshwater cooling and groundwater seepage. The amount of copper in the effluent attributable to these sources was, however, minimal.

Non-contact cooling water can pick up copper from the ambient water around the intake, the components of the piping systems that are used and any contaminants that are on the dry dock floors. These estimates indicate that controlling particles in the floors, walls and drainage system of the dry docks have the largest potential to reduce the copper load in the effluent.

In addition to evaluating the discharge, the receiving water was also evaluated for any impacts. Elevated copper levels were not observed at any station in Pearl Harbor as a result of the current copper loadings into the water body. (See Figure 1.) Dissolved copper concentrations in the harbor had an overall mean of 0.62 µg/L. The highest concentration was observed from a sample taken during a rain event and did not exceed 1.3 µg/L. All measured concentrations were less than half of the current Hawaii Water Quality Standard (WQS; 2.9 µg/L) and well below the current acute EPA Water Quality Criterion (WQC; 4.8 µg/L) for the protection of aquatic life in ambient water. (See Figure 2.) The nontoxic effect of these low dissolved copper concentrations was corroborated by the absence of ambient toxi-

city in all samples and for all species examined throughout this study. These results indicate that copper loadings from the shipyard to Pearl Harbor do not create impaired conditions.

## BEST MANAGEMENT PRACTICES

BMPs are activities taken to reduce contaminant loads and protect water quality. As with most naval facilities, effective BMPs at the shipyard are already being implemented in comprehensive pollution prevention programs such as material substitutions, secondary containment and cleanup procedures with the specific goal of reducing contaminant contributions to the shipyard effluents. A critical aspect of implementing new BMPs and procedures that is often overlooked is to properly quantify, evaluate and understand the effectiveness of each BMP before it becomes standard operating procedure. This evaluation should include applying human factors to make sure that practices and equipment will actually be used as well as a quantification of the efficiency and cost of the BMP. A technology can be highly efficient, but if it only addresses a small percentage of the overall loading, it may not be a cost-effective means to address pollution and support operations.

FIGURE 1: Sampling stations for the Pearl Harbor Estuary.
Google Earth modified image

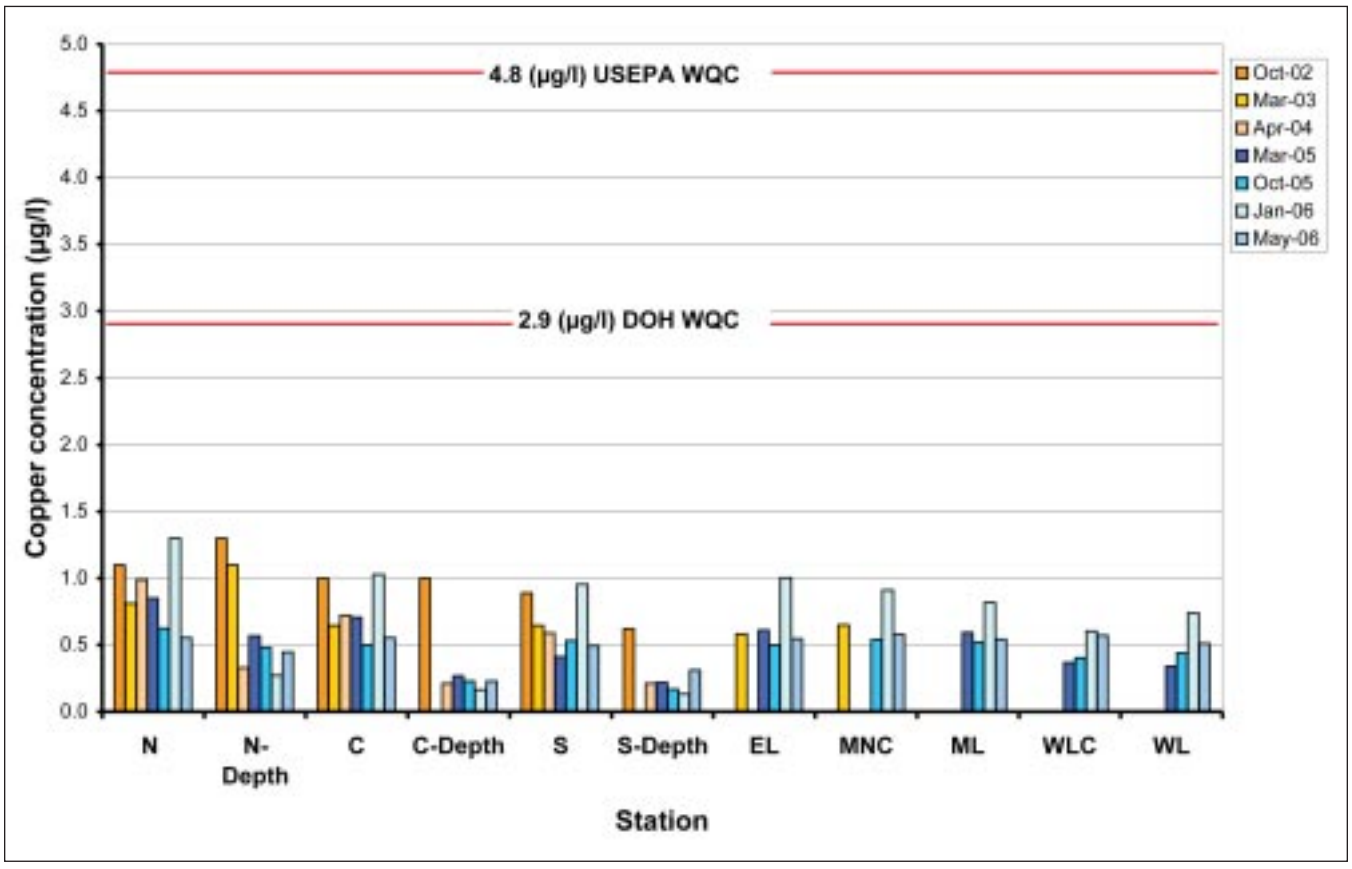


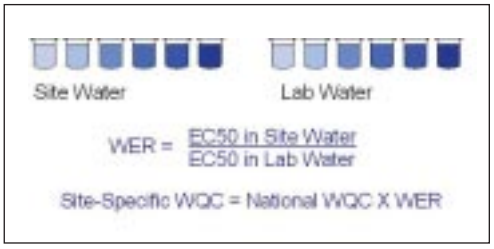

FIGURE 2. Seasonal dissolved copper concentrations throughout the Pearl Harbor Estuary.

Since particulate matter is the most significant contributor to the high copper load in the effluent, additional efforts at the shipyard are focused on more frequent and effective dry dock cleaning methods.

## WATER EFFECT RATIO

A WER is a final step that a permittee can take to account for local conditions in an NPDES permit. The WER uses standardized toxicity testing to compare the effects that laboratory and local site water constituents have on increasing or reducing the pollutant bioavailability and toxicity in side by side comparisons. This procedure results in a ratio that is multiplied by the national criterion to derive a site-specific criterion. The objective of a WER is to modify the State WQS for a site-specific Water Quality Objective and establish new permit limits that reflect the protective requirements necessary for a permittee's receiving water body (in this case Pearl Harbor).

A WER study was conducted using embryos of sensitive marine invertebrates as a means of deriving a site-specific WQC for copper (currently 2.9 µg total recoverable copper/L in the State of Hawaii) for




The use and application of a WER.

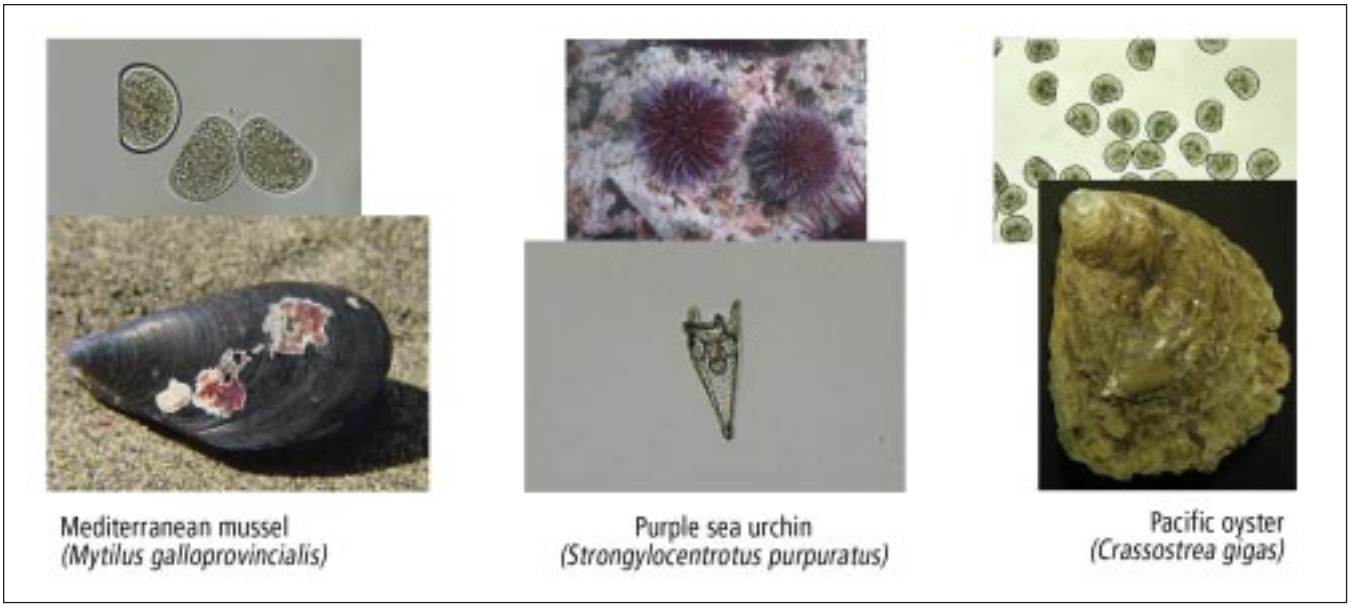



FIGURE 3: Test species and their larvae used for WER toxicity testing.

Mediterranean mussel.
www.rpgroup.caltech.edu

Pearl Harbor. The investigation involved extensive toxicity testing associated with four sampling events at eight different locations throughout the harbor during March 2005 through May 2006. (See Figure 1.) Based on EPA guidance, the study used the Mediterranean mussel (*Mytilus galloprovincialis*) as the primary species and the purple sea urchin (*Strongylocentrotus purpuratus*) and the Pacific oyster (*Crassostrea gigas*) as secondary corroborative species. (See Figure 3.)

Purple sea urchin.

**Pearl Harbor waters provide significant protection to aquatic species relative to the baseline laboratory toxicity tests utilized for the development of the state and national standards.**

The final WER values indicate that Pearl Harbor waters provide significant protection to aquatic species relative to the baseline laboratory toxicity tests utilized for the development of the state and national standards.

## COPPER TRANSLATOR

Permit limits are generally expressed in total recoverable metals. It is now the policy of the EPA that the use of dissolved metal to set and measure compliance standards is the recommended approach, because dissolved metal more closely approximates the biologically active fraction of metal in water than does total recoverable metal.

The translator is essentially a conversion factor for ambient WQS, expressed as dissolved metal, and applied to a permit limit that is expressed as total recoverable metal. A permittee can use the ratio published by EPA for this conversion, or they can perform the tests to calculate their own.

SSC Pacific examined the partitioning of copper in mixtures of discharge effluent and ambient receiving water during seven separate sampling events. Factors that were critical to the success of the field design included the parameters for measurement, location of the sampling stations, sampling schedule, number of samples collected, use of appropriate clean sampling techniques, data analysis and translator calculation.

The translator was calculated as the mean of the measured values for 1:1 mixtures of effluent and ambient waters. The mean dissolved-to-total ratio (i.e., the translator) was 62 percent for copper, lower than the EPA's published default ratio of 83 percent. Therefore, a substantial portion of the total copper (38 percent) in the dry dock effluents entering Pearl Harbor is not in the dissolved fraction and therefore not biologically active. These results were applied to the permit calculation process to convert the permit limit into total recoverable copper.

## APPLICATION OF A MIXING ZONE

The shipyard has an occasional need to use large volumes of cooling water to support commercial ship industrial operations conducted by a contractor during private/public

An NPDES-permitted discharge at the Pearl Harbor Naval Shipyard.
Photo by Glenn Atta

ventures. The discharge into the surrounding water during those operations can be above the regulatory limit of one degree from ambient. To enable the occasional release of higher temperature water during these operations, the shipyard submitted an application for a thermal mixing zone, which included a comprehensive hydrodynamic modeling effort by SSC Pacific to evaluate the effects and attenuation of the thermal plume and to establish a thermal mixing zone.

## THE FINAL RESOLUTION

The shipyard was issued an NPDES permit by the Hawaii Department of Health with a final limit of 50 µg /L for copper and an allowance for a thermal mixing zone for occasional high volume thermal discharges. This final permit limit requires some rulemaking efforts to adjust the Hawaii Administrative Rules to incorporate the results from both the WER and recalculation procedures. This is expected to take at least another year. In the end, this is not a free pass for the shipyard, but it is a permit limit that the shipyard can work with. Compliance with the limit will require constant vigilance and ongoing efforts to evaluate process waste streams and control pollution.

None of these studies or efforts would be possible without a constant dialogue with the regulatory authorities—they had active participation in the designation of sampling stations, and were informed on the different elements of this study and the results. This comprehensive effort demonstrates the scientific and technical capabilities at SSC Pacific and the commitment of the PHNSY & IMF facility personnel to protect the environment, comply with regulatory requirements and keep the Fleet fit to fight.

Additional information on the capabilities of SSC Pacific can be found at http://environ.spawar.navy.mil. The full report entitled "A Comprehensive Copper Compliance Strategy: Implementing Regulatory Guidance at Pearl Harbor Naval Shipyard & Intermediate Maintenance Facility" by Earley, P.J. et. al is available at http://environ.spawar.navy.mil/Publications/pubs2.html.

## FOR MORE information

For more information on the role of these and other organisms in toxicity studies, please see our article entitled, "Tiny Organisms Play Large Role in Toxicity Studies: Larvae Are Useful Indicators of Marine Environmental Quality" in the summer 2007 issue of *Currents*. You can browse the *Currents* archives on the Naval Air Systems Command's environmental web site at www.enviro-navair.navy.mil. *Currents* is also available on the Defense Environmental Network & Information eXchange (at www.denix.osd.mil) via the "Publications/Source/Navy/Currents" and "Publications/Frequency/Quarterly/Currents" links.


## CONTACT

**Patrick Earley**
SPAWAR Systems Center Pacific
619-553-2768
DSN: 553-2768
patrick.earley@navy.mil